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FY 1986/FY 1987

**Final Technical Report**

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July 15, 1986 - December 30, 1989

Prepared by

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# **DOD-University Research Instrumentation Program**

**FY 1986/FY 1987**

## **Final Technical Report**

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**University of California**  
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### **I. INTRODUCTION AND OBJECTIVE**

Professor Chen Tsai's group at UC Irvine have over the years conducted a large number of DOD-sponsored Research Projects on Integrated Optics. These research projects concern conception, experimentation, and realization of new and novel guided-wave optic devices and modules with applications to wideband multichannel integrated/fiber optic communication, computing, and radar signal processing systems. For this purpose, sophisticated instrumentation is required for fabrication of test devices and modules with complex geometry at micron or submicron dimensions. Professor Tsai has established a microfabrication facility from scratch since joining UCI nine years ago.

The objective of this DOD/AFOSR - University Research Instrumentation Program was to purchase and install a scanning electron microscope (SEM) system that is essential for examination and characterization of the detailed dimensions and structures of the integrated optic devices and modules that have been fabricated and explored. A SEM system has been established and put into use since October 1989.

## II. SCANNING ELECTRON MICROSCOPE (SEM) SYSTEM

### A. Major Components of the SEM system

The SEM system acquired consists of the following major components:

1. Model SR-50/A basic SEM system by Applied Beam Technology/International Scientific Instruments	\$50,580
2. E-beam blanker unit by Applied Beam Technology/International Scientific Instruments	\$11,450
3. Model 5000-2 energy dispersive X-ray (EDX) system by Hnu System, Inc.	\$48,000
4. Laserwriter, IINT by Apple computer	\$3,180
5. Closed loop water cooling system for the diffusion pump of the SEM basic system, in-house design and implementation	\$1,000
6. Model Hummen 6 sputtering by Anatech	<u>\$3,500</u>
Total	\$117,710

In addition to the expenditure for the major components listed above, some \$20,000 was spent in connection with renovation of the laboratory and purchase of miscellaneous items. A matching fund of some \$30,000 was provided by University of California at Irvine toward this SEM project.

### B. Technical Discussion On the SEM System

The complete system has been put together, installed, and tested. It occupies 200 square feet of floor space in a well-conditioned laboratory. The system is currently in good operating condition (see photograph). In order to cool the diffusion pump of the basic SEM system, an innovative closed-loop water system was designed and implemented at a minimum cost. The water in the loop is pumped by an immersion pump. The returned water is discharged to a 50-gallon drum where the immersion pump is housed to complete

the loop. If the room air is used to cool the water in the drum, the water temperature stays at about 35°C which is higher than required. Thus, a heat exchanger is immersed in the drum to cool the water. The heat exchanger is circulated with chilled water available in the laboratory. Consequently, the water in the drum is reduced to 20°C which is quite satisfactory. Since the water is in a closed loop, we can afford to use high quality water, thus preventing the clogging of the water line in the SEM system. If leakage in the loop occurs, the amount of water which will leak on the floor would be only 50 gallons, which will result in at most 1.7cm of water level on the floor. The implementation of the closed loop cooling system thus would extend the useful life of the SEM system and ensure safety.

Major functions of the system are now described. The SEM unit takes electronic images of specimens. For specimens which are highly insulating, such as  $\text{LiNbO}_3$  and glass, a thin layer of gold-palladium is first sputtered on the specimen using the Hummen 6 sputtering unit to prevent charge build up on the specimen surface. The Hnu EDX system has frame grabber which digitizes and store the images in a PC/AT computer. The stored images can then be retrieved and processed to obtain a variety of informations on the images. They can also be printed on regular papers using the laser printer, and/or displayed on a color monitor for examination or taking pictures with a 35mm camera.

The X-ray detector of the EDX system is mounted on the chamber of the basic SEM unit, taking up one port of the chamber. The detector is cooled with liquid nitrogen all the time to prevent the drift of Lithium element in the detector. The EDX system has the capability of analyzing the elements with atomic number greater than 10. It thus gives an estimate on the chemical composition in a very small area of the specimen surface. Therefore, the EDX system greatly enhances the capability and performance of the system.

The EDX system also has electrical interfaces to control the position and scanning of the electron beam of the SEM unit using digital signals. When this function is coupled with the E-beam blanker unit, the electron beam can be controlled in position, and turned on and

off. Thus, the system possesses the basic functions required for electron beam lithography in the future. However, a great deal of work is still needed to write the computer codes to control the electron beam position and scanning speed, and to synchronize its switching with its movement in order to generate a desired exposure pattern for lithography.

### III. USERS OF THE SEM SYSTEM

The regular users of this SEM system include the graduate students and the research staffs of the Optical/Solid-State Devices Group of the Department of Electrical and Computer Engineering. Some graduate students from the Departments of Physics and Chemistry have also occasionally used the system. Faculty and graduate students from the Department of Mechanical Engineering plan to use this facility in the near future.

